Responsive Music Interfaces for Performance

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Abstract

In this project we have developed reactive instruments for performance. Reactive instruments provide feedback for the performer thereby providing a more dynamic experience. This is achieved through the use of haptics and robotics. Haptics provide a feedback system to the control surface. Robotics provides a way to actuate the instruments and their control surfaces. This allows a highly coordinated "dance" between performer and the instrument. An application for this idea is presented as a linear slide interface. Reactive interfaces represent a dynamic way for music to be portrayed in performance.

Keywords: haptics, robotics, dynamic interfaces

1. Introduction

This paper presents a method for the design of musical interfaces intended to maintain the versatility of a studio-style control surface but enhanced with mechanisms to add to the liveliness of the performance and the stage-presence of their use. We present an example interface, an augmented slider controller that through actuation can create both adversity and symbiosis with the performer adding new physicality to the show. These types of interfaces enable new performance styles and can be used to add physical expression to the compositional process.

2. Background

2.1 Haptics in Music Interfaces

It has been shown that haptic feedback allows the player to more articulately express their artistic intention [1]. It has also been shown that haptic feedback improves music motor learning [2]. Our focus is on active haptic feedback as a means to richly enhance the performance experience for both the performer and the audience.

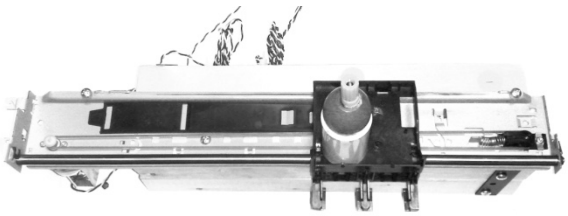

Figure 1. Slide Device

2.2 Robotics in Music Interfaces

There exists a rich history of robotics in music interfaces, such as the work of Trimpin and his SoundSculptures [3].

Robots can become players either when they manipulate an already established control surface or modify a control input to that surface. A control surface can be anything from a Theremin to the string of a guitar. In "A Music Playing Robot" it is shown that it is possible to control a robot precisely enough using a closed control loop that it can fully control a Theremin [4]. Our approach puts the user inside this type of control loop so that they can modify the "playing" of the robot in real time.

3. Example Slide Control Application

Merging aspects from robotics and haptics into one system enables the design of interfaces that allow the performer to become part of the control and feedback loop. The example system described below is composed of a robotic actuator, a sensor package, and a processor.

The actuator consists of a carriage on a linear slide. This carriage contains the control surfaces for user input. The carriage is propelled by a toothed belt attached to a DC motor. This motor is connected to an encoder for positional feedback (See Figure 1). This setup turns the device into a scalable linear servo.

If left without interaction, the robot would continuously loop and move to positions according to a musical composition. The position of the carriage can be mapped to tone, frequency, timbre, or any other programmable parameter. These positions can either be programmed into the computer or set manually through the appropriate buttons on the control surface. To set manually, the user moves the control surface into the desired position and depresses the record button. This marks the position and time. When the user is done entering in their sequence, the robot then plays it back in a continuous loop. This essentially mimics what the user has just done. Otherwise, the position can be controlled by OSC and/or MIDI over USB. This function is similar to a standard motorized linear potentiometer on automated mixers. However, this system supports additional dynamic haptic feedback to the user.

This feedback is provided as either force feedback or texture feedback. Each has its advantage for augmenting user control and when both are combined complex effects can be achieved.

Force feedback is provided by the motor either pulling or pushing the control surface. For example, if the slide is set up for position to frequency control, the slide could push the user's hand toward one note and away from another. The performer could then fight with this change in order to modify the music. This fighting action provides a spectacle for the audience as it is immediately apparent what is occurring as the instrument is resisting change and trying to force the performer to its whim. The more the performer pushes, the more the robot fights back. The performer can use this virtual adversary as a means for expression. The resulting music reflects this tension as the fight between performer and interface unfolds.

Texture feedback is provided by creating artificial surfaces and features within the software. Similar ideas were expressed in "THE PLANK: Designing a simple haptic controller" [5]. These effects can be arbitrarily programmed into the device from software with an unlimited selection of types available including types that hinder the performer.
In Figure 2 some detent topologies are shown:

- "Smooth Valley" - the user gets non linearly pulled toward the detent point and then must apply a non-linear pressure to escape it. Analogous to pushing something through a bowl.
- "Smooth Hill" - the user gets non linearly pushed away from the detent point and then is pushed non linearly away from the detent point. Analogous to pushing something over a smooth hill.
- "Mountain Peak" – the user gets linearly pushed away from the detent point and then is pushed linearly away from the detent point. Analogous to pushing something over a roof.
- "Ratchet" – the user gets linearly pushed away from the detent point and then is pushed sharply away from the detent point. Analogous to a ratchet action
- "Soft Incline" – the user is softly pushed away from the detent point.
- "Soft Decline" – the user is softly pushed away from the detent point.

The detents are simulated by the control system, which provides the appropriate motor torque and speed in relation to the positional information feedback and the recorded composition information.

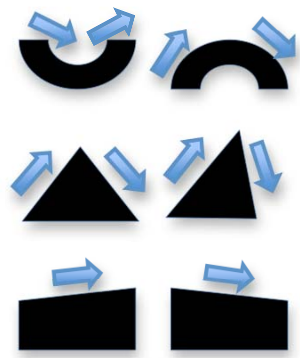

Figure 2. Detent Topology

The system accomplishes this via a control loop. The current position is read by the encoder and sent to the processor. The processor determines how to move the control surface in order to both reach the desired position and create the specified effect. The processor sends control data back to the computer for sound synthesis. This information is then sent to the motor control that physically moves the control surface. This is where the user can interrupt this loop by physically grabbing and manipulating the control surface.

Since this motor-feedback combination need not necessarily be a linear slide, it can be adapted and scaled to various other instruments and actuators without the need for redesign of the core system.

4. Acknowledgments

We wish to thank the MIT Media Lab, Mark Feldmeier, Nan-Wei Gong, Michael Lapinski, Matt Aldrich, Bo Morgan and Amelia Servi.

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